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Interaction and Analogy in the Comprehension and Appreciation of Metaphors

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Running head: Metaphor

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Abstract

Two experiments tested a theory of information processing in metaphoric comprehension and appreciation. According to this theory, certain kinds of metaphors are based upon underlying analogies, and the processing components used to interpret these metaphors are highly similar to those used in the interpretation of analogies. A critical difference in the two kinds of information processing, however, is in the interaction of tenor and vehicle in the interpretation of a metaphor; a comparable interaction does not occur in the interpretation of the domain (first half) and range (second half) of an analogy. In the first experiment, modeling of latencies for comprehending analogies and corresponding metaphors showed that information processing was similar, but not identical, in the two tasks. In the second experiment, comparisons between different metaphoric forms showed that the proposed theory could account for findings of the aptness and comprehensibility of various metaphors, and that making more clear the identities of the terms of the analogy underlying a metaphor and the nature of the interaction between tenor and vehicle increases both the aptness and the comprehensibility of a metaphor.

Interaction and Analogy in the Comprehension and Appreciation of Metaphors

In comprehending and appreciating a metaphor, we conceive of something new in terms of something old. In the metaphor "Man is a wolf," for example, the new term, or tenor of the metaphor, man, is seen in terms of the old term, or vehicle of the metaphor, wolf. The basis for the comparison between man and wolf, or ground of the metaphor, is left implicit. Indeed, the extent to which one will comprehend and appreciate the metaphor will depend in large part upon the extent to which one can ascertain what the ground or grounds are that relate(s) the two terms of the metaphor. In this and other metaphors, "newness" and "oldness" refer to ways of seeing things, rather than to the things themselves. For example, almost everyone will have been familiar with many of the properties of men and wolves prior to seeing the metaphor for the first time; but at least some of these people will not have thought about the properties of men in terms of the properties of wolves.

Because the conception of something new in terms of something old forms the basis for analogical thinking as well as for metaphorical thinking, and because analogical thinking has generally been thought to comprise a broader range of mental phenomena than has metaphorical thinking, some students of metaphor have been inclined to view metaphoric understanding as a form of analogical thinking (e.g., Aristotle, 1927; Billow, 1975; Gentner, 1977; Miller, 1979; Sapir, 1977; Sternberg, Tourangeau, & Nigro, 1979). On this view, the metaphor "man is a wolf" can be viewed as an implicit analogy in which the properties of a man are seen as relating to a man in a way analogous to that in which the properties of a wolf are seen as relating to a wolf. There are a number of specific viewpoints that are consistent with the general framework in which metaphors are seen as based in some way upon underlying analogies. Two specific viewpoints of particular contemporary interest are the comparison

and interaction ones (cf. Tourangeau & Sternberg, Note 1).

Strict comparison theorists view metaphors as essentially analogies with missing terms, and nothing more. Miller's (1979) view of a metaphor "as a comparison statement with parts left out" (p. 226) comes close to this strict comparison view, as does his quotation of the definition of a metaphor in Webster's New International Dictionary (2nd ed.): "'A metaphor may be regarded as a compressed simile'" (cf. Miller, 1979, p. 226). Indeed, Miller sees as a major goal of his theorizing a response to Black's (1962) criticism that the comparison view of metaphor "suffers from a vagueness that borders on vacuity" (p. 37). Miller proposes that "the comparison view of metaphor can be made considerably less vague" (p. 227), and indeed, Miller does clarify the comparison point of view. For example, Miller suggests that underlying the metaphor, "The lion is the king of beasts," is the incomplete analogy, "lion : beasts :: king : ?." Other metaphors, such as "Britain was the ruler of the waves," "George Washington was the father of his country," and "André Weil is the Bobby Fischer of mathematics," can be understood in the same way, namely, as implicit and incomplete analogies. As one can make the transition from a metaphor to an analogy, so can one make the transition from an analogy to a metaphor. An analogy such as "toes : foot :: fingers : hand" can be re-formed into a metaphor, "The toes are the fingers of the foot," where the fourth term of the analogy, "hand," is left implicit. Miller provides a detailed formal analysis of these kinds of proportional metaphors that shows their proposed basic isomorphism to analogies.

Interaction theorists can view analogies as underlying metaphors, but they propose that to view metaphors as nothing more than analogies with missing implicit terms is to miss the essence of metaphor. Richards (1936), for example, has suggested that "when we use a metaphor we have two thoughts of different

things active together and supported by a single word, or phrase, whose meaning is a resultant of their interaction" (p. 93). Richards has further viewed metaphor as "fundamentally a borrowing between and intercourse of thoughts, a transaction between contexts" (p. 94), and as requiring two ideas "which co-operate in an inclusive meaning" (p. 119). On this view, then, metaphor is more than an analogy with missing parts. In Black's (1962) terms, "the new context...imposes extension of meaning upon the focal word" (p. 39). One's interpretation of the tenor changes as a result of the tenor's interaction with the vehicle. Consider, for example, the metaphor "Man is a wolf." On the comparison view, a person might be seen as mapping properties of a wolf onto a man, and seeing the extent to which they fit. On the interaction view, a person might be seen as reorganizing his or her views about men in terms of wolf-like properties.

> A suitable hearer will be led by the wolf-system of implications to construct a corresponding system of implications about the principal subject. But these implications will not be those comprised in the commonplaces normally implied by literal uses of "man." The new implications must be determined by the pattern of implications associated with literal uses of the word "wolf." Any human traits that can without undue strain be talked about in "wolf-language" will be rendered prominent, and any that cannot will be pushed into the background. The wolf-metaphor suppresses some details, emphasizes others--in short, organizes our view of man. (Black, 1962, p. 41)

Do people attempting to understand and appreciate metaphors actually treat some subset of them analogically, representing information and then processing it in ways similar to those used in the representation and processing of information in the solution of analogies? If so, is there an interaction between the tenor and vehicle of the metaphor? We shall consider each question in turn.

Several empirical investigations have suggested that analogies can underlie metaphorical statements.

Tourangeau and Sternberg (in press) tested a refined and augmented version of a theory of mental representation in metaphorical reasoning first explicated by Sternberg, Tourangeau, and Nigro (1979). The theory of representation is based upon that applied to analogical reasoning by Rumelhart and Abrahamson (1973) and extended to other forms of inductive reasoning by Sternberg (1979, 1980) and Sternberg and Gardner (Note 2). On this view, information can be represented by means of a multidimensional "semantic space" in which each dimension represents some graded characteristic of the set of concepts under consideration (Fillenbaum & Rapoport, 1971; Henley, 1969; Rips, Shoben, & Smith, 1973; Rumelhart & Abrahamson, 1973).[1] We found it necessary to generalize the notion of a semantic space by introducing a concept of "orders" of spaces so as to accommodate our theory of what makes some metaphors more apt than others. These orders represent the various levels of abstraction of the terms of the various spaces. For example, mammals and birds might each form subspaces in a hyperspace of animals. We tested our representational theory in two experiments. In Experiment 1, subjects rated the aptness of metaphors such as "A wildcat is a hawk among mammals." The prediction relevant in our present context was that metaphors would be rated as more apt to the extent that the location of the tenor (here, "wildcat") in its semantic subspace (here, "mammals") was analogous to the location of the vehicle (here, "hawk") in its subspace (here, "birds"). In other words, the terms of the metaphor were hypothesized to form a cross-subspace analogy (see also Rips, Shoben, & Smith, 1973). This prediction was confirmed. In Experiment 2, metaphors were presented in a format exemplified by "A wildcat is a _____ among mammals," where multiple possible response options were provided for the missing term, e.g., "(a) robin, (b) ostrich, (c) hawk, (d) bluejay." Subjects were asked to rank-order the options in terms of their goodness of fit. An exponential model of response choice

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such as that used for analogies by Rumelhart and Abrahamson (1973) was found to provide a good fit to the response-choice data.

Billow (1975) presented children in the age range from 5 to 13 with proportional metaphors such as "My head is an apple without any core." These metaphors were hypothesized to have implicit analogies underlying them, in this case, "head : apple :: brain : core " The subject's task was to interpret each metaphor as accurately as possible. Many of the errors subjects made in comprehending the metaphors were identical in kind to errors made by children in comprehending analogies (see Achenbach, 1970; Gallagher & Wright, 1979; Lunzer, 1965; Piaget with Montangero & Billeter, 1977; Sternberg & Nigro, 1980), for example, global interpretations, associative responding, or convergences on similar features between elements. Some responses showed partially successful efforts to deal with the underlying proportion; for example, elements of the proportion were added, but they were the wrong elements.

Gentner (1977) presented individuals from the preschool to the college level with pictures, and then required the individuals to reason metaphorically about the pictures. For example, she might show the individuals a picture of a mountain, and then ask them, "If this mountain had a knee, where would it be?" In an initial study, she found that preschool children could map such body parts to the inanimate objects as well as adults could do so. She then made the task more difficult by varying the orientation of the pictured objects or by adding misleading features to these objects. In this situation, children actually performed somewhat better than adults. Gentner concluded that even preschool children possess the ability to use analogy in understanding simple metaphors such as those in her study.

Winner, Engel, and Gardner (1980) presented metaphorical grounds in five different linguistic (surface-structural) formats: predicative metaphors (e.g., "The skywriting was a scar marking the sky"), topicless metaphors (e.g., "The _____ was a scar marking the sky"), similes (e.g., "The skywriting was like a scar marking the sky"), quasi-analogies (e.g., "A scar marks the skin and _____ marks the sky"), and riddles (e.g., "What is like a scar but marks the sky?"). Subjects--children aged 6, 7, and 9 years--were asked either to explain the meaning of the sentence, to fill in the blank, or to answer the question. There were two basic conditions in which these tasks were presented. In one, the subject had to fill in a blank or to answer a question, as appropriate; in the other, the subject had to choose the best of four alternative answer options. The investigators found that topicless metaphors were of about the same difficulty as the quasi-analogies in the first, explication condition, but more difficult than the analogies in the second, multiple-choice condition. The second finding confirmed their prior prediction that topicless metaphors would be more difficult than analogies; the first finding did not confirm their prior prediction.

Turning now to the second question posed earlier -- that of whether there is an interaction between the tenor and vehicle of a metaphor -- we offer what we consider to be at least tentative evidence that a metaphor differs from a straightforward analogy in the presence of an interaction between the domains of its tenor and vehicle.

Malgady and Johnson (1976) presented subjects with metaphors couched in five different formats. In one format, nouns in the metaphors were modified

by adjectives that related to both of the nouns, e.g., soft hair and shiny silk; in a second format, nouns in the metaphors were modified by adjectives that related only to the individual nouns to which they were paired, e.g., long hair and elegant silk; in a third format, each noun in a metaphor was modified by an adjective that was inappropriate to that noun, but that was appropriate to the other noun in the metaphor, e.g., elegant hair and long silk; in a fourth format, nouns in a metaphor were modified by adjectives that were not related to either noun, e.g., distant hair and fatal silk; and in a fifth format, the metaphor consisted only of two unmodified nouns. In three parts of an experiment, subjects were asked either to give similarity judgments between groups of words, to rate goodness of metaphors, or to interpret metaphors. The authors found that it was possible to predict metaphor goodness and interpretability from changes in similarity induced by different patterns of adjective modification. Metaphor goodness and interpretability were highest where both adjectives were consonant with both nouns (e.g., soft hair and shiny silk could be recast as shiny hair and soft silk and still make sense), and respectively lower as overall consonance between adjectives and nouns decreased. Most relevant here was the finding that goodness and interpretability were lower when adjectives were consonant with the noun they were modifying but not the other noun that they were not modifying than when adjectives were consistent with both nouns. Malgady and Johnson interpreted these results as being consistent with Johnson's (1970) proposal that

> elementary cognitive features which encode the meaning of each metaphor constituent are summed to form a single representation, qualitatively distinct from that of the constituents. As Johnson, [Malgady, and Anderson (Note 3)] suggested, the act of juxtaposing two words, whether in word association or metaphor, creates a single meaning. (Malgady & Johnson, 1976, p. 51)

Verbrugge (1977) has made a proposal similar to that advanced by Black (1962) and by Johnson et al. (Note 3), namely, that metaphor "involves a fusion of both events [tenor and vehicle], and thus a transformation or warping of each domain according to the particular constraints of the other" (p. 385). Verbrugge based this position on a series of studies of prompted recall by Verbrugge (Note 4) and by Verbrugge and McCarrell (1973), in which people, when given metaphors such as "skyscrapers are the giraffes of a city," actually visualized a huge giraffe in the middle of a city skyline, with the neck of the giraffe extending far above the "other" buildings. The more compatible the tenor and vehicle were, the more the fusion that took place.

To conclude, there is at least some evidence to suggest that (a) at least some metaphors are processed in ways highly similar to the ways in which analogies are processed, and that (b) to the extent there is dissimilarity, it may be due in part to a special kind of interaction between tenor and vehicle that takes place in analogical correspondences that are peculiarly metaphoric in nature. The present article seeks to extend the theoretical and empirical data base supporting these contentions. In particular, a metaphor is seen as based upon an underlying analogy for which some of the terms may be implicit, but is seen as differing from this analogy in the interaction of the tenor with the vehicle. Whereas this view probably does not apply to all possible metaphors, it seems to apply to a large and interesting enough subset of them to make pursuit of the point of view worthwhile.

The present article may be viewed as a companion paper to the Tourangeau and Sternberg (in press) paper, in that whereas that article refines and augments the representational theory of metaphor presented in

Sternberg, Tourangeau, and Nigro (1979) and Tourangeau and Sternberg (in press), the present article refines and augments the information-processing theory presented in Sternberg, Tourangeau, and Nigro (1979). This theory uses as its conceptual basis the theory of analogical reasoning processes proposed by Sternberg (1977a, 1977b); the theory has since been extended to other forms of inductive reasoning processes as well (Sternberg, 1979, 1980; Sternberg & Gardner, Note 2). A discussion of the interface between representation and process in metaphoric comprehension and appreciation can be found in Sternberg, Tourangeau and Nigro (1979).

Information-processing Theory of Metaphoric Comprehension

On the present view, the information-processing components used to comprehend "proportional" metaphors (which are believed to constitute a large subset, but certainly not the whole set, of metaphors) are highly similar to those used to comprehend analogies. We will consider first how the theory applies to analogies, and then extend it to various kinds of metaphors.[2]

Analogies

Consider an analogy presented earlier as re-expressed in multiple-choice format: "lion : beasts :: king : (a) rulers, (b) humans." An individual solving this analogy must *encode* the terms of the problem, identifying the terms and retrieving from long-term memory the attributes that may be relevant for analogy solution. The individual must also *infer* the relation between the first two analogy terms, ascertaining what relation "lion" bears to "beasts." Next, the individual must *map* the higher-order relation that links the domain (first half) to the range (second half) of the analogy, ascertaining, for example, that the analogy is about the roles of lions and kings in their respective domains. Then, the individual takes the relation previously inferred from the first to the second term of the analogy and as mapped to the third term (second half) of the analogy and *applies* it from the third term in order to generate an ideal possible completion of the analogy. Suppose, for example, that a given subject

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imagines this ideal completion to be "people." Then this term will be generated as a proposed completion. The individual must now compare the two (or whatever number of) answer options to the ideal in order to determine which is correct. If neither is identical to the ideal, as in the present instance, then the subject must justify one of the options, here, "human," as closer to the ideal, although not itself the ideal. Finally, the subject must respond, communicating his or her response to the outside world.

Metaphors

All terms of underlying analogy explicit. Suppose the basic proposition relating lions to kings had been stated in the form, "A lion among beasts is a king among (a) rulers, (b) humans." In this event, the information-processing components needed to comprehend the metaphor are proposed to be the same as those required to comprehend the analogy described earlier. The subject must encode the given terms, infer the relation of lion to beasts, map the higher-order relation that links a lion in its domain to a king in its domain, apply the previously inferred relation as mapped to the new domain to generate an ideal answer, compare this answer to each of the alternatives, justify one of the given answers as better than the other, although possibly nonideal, and respond. The theorized identity of components does not imply equivalence in the difficulty of the metaphor and its corresponding analogy. On the one hand, the additional verbal material contained in the metaphor increases the reading load of this presentation format; on the other hand, this additional mediating context may make the metaphor more readily comprehensible. Hence, the relative difficulties of the two presentation formats will depend upon the relative effects of increased reading load and increased mediating context. Normally, we would expect the presentation of more mediating context to increasing processing latency (through added reading time) at the same time that it increases rated comprehensibility of a metaphor.

Some terms of underlying analogy implicit. Proportional types of metaphors are often presented in ways that leave at least some of the terms of the underlying analogy implicit. The "lion and king" metaphor, for example, could be presented in any of the following formats (among others), where either no terms or some terms are left implicit:

1. A lion among beasts is a king among people.
2. A lion among beasts is a king.
3. A lion is a king among people.
4. A lion is a king.
5. A lion is a king among beasts.

Multiple-choice format could be introduced into these metaphors by allowing multiple answer options in place of a single last (or other) term. The exact set of components used would depend upon the response format. Comparison and justification, for example, are used only if multiple-choice rather than free-response format is used. Where in the metaphor the components are actually executed can also vary as a result of presentation format. In the metaphorical forms, "A lion is a king among _____" and "A _____ is a king among beasts," inference occurs in the vehicle, since it is a term in the topic that is missing. Inference of relations in the vehicle is actually fairly common, since it is the new information in the tenor that is presented most often in terms of the old information in the vehicle: One infers relations between known elements and then applies them to unknown elements.

An important thing to notice in these various metaphorical forms is that different terms are left implicit in different forms of presentation. These different forms may differ in their comprehensibility, as well as in their aptness, as a function of the terms that are left implicit, and, in the fifth form, as a function of the reordering of terms: "Beasts," the second term of the implicit analogy, is presented last. On the present theory, the reason for

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these variations in comprehensibility and information-processing difficulty would be found in the fact that these forms require not only comprehension of the explicit terms and of the relations that can be formed between these terms, but also the generation of terms that are left implicit, and the comprehension of relations between these pairs of terms (as well as between implicit and explicit ones). Miller (1979) seems to share a similar view.

As mentioned earlier, there are two possible effects of presenting additional context on comprehensibility. One is that reading load may be increased, presumably adding to processing time if not difficulty; the other is that the need to generate new terms can make processing of metaphors more difficult either through the sheer time and effort expended on this generation, or through the generation of incorrect terms, which can reduce the meaningfulness of the metaphor. Overall, adding additional terms should probably increase processing latency, but also increase comprehensibility by making more clear the nature of the implicit analogy.

The effects of presenting additional context on aptness can also work one of two ways: On the one hand, part of the satisfaction one derives from a metaphor may result from the insertion of missing terms--in effect, one actively participates in the construction (for oneself) of the metaphor; on the other hand, subjects' incorrect or inadequate constructions may decrease the aptness of the various forms, or aptness may be decreased by the subject's failure to make the constructions at all. Given the positive relationship between aptness and comprehensibility (Tourangeau & Sternberg, in press), we would expect that the increase in context should increase the aptness of a metaphor by making more clear what the underlying analogy is, and by decreasing the risks of mistakes in insertion of terms.

Relations between comprehensibility and aptness. As mentioned above, comprehensibility and aptness of metaphors are positively related: Tourangeau and

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Sternberg (in press) found them to be highly correlated, and found that ratings of comprehensibility increased predictability of ratings of aptness, even after all parameters of their representational theory were entered into the prediction equation (but see Gerrig and Healy (Note 5)). On our theory, aptness is in part a function of comprehensibility. A metaphor cannot be viewed as apt if it is not understood. One way of increasing comprehensibility is to increase the number of terms of the underlying analogy that are made explicit rather than left implicit; a second way is to make more clear or vivid the nature of the interaction between tenor and vehicle. Resulting increases in comprehensibility should lead to derivative increases in aptness.

Interaction. We suggest that quality and clarity of interaction between tenor and vehicle in a metaphor can increase the aptness of that metaphor, beyond the aptness attained by the quality and clarity of the analogy underlying the metaphor. Hence, any manipulation that increases the probability of a subject's appreciating the interaction between tenor and vehicle should increase aptness of a metaphor.

Hypotheses. We performed two experiments to investigate several hypotheses suggested by the theoretical analysis above, namely:

1. The information-processing components used in the understanding of metaphors and especially metaphors with relatively fewer implicit terms should be highly overlapping with the components used in the understanding of analogies.

2. Metaphors should become more comprehensible and be viewed as more apt as

a. the number of terms of the underlying analogy that are made explicit is increased, thereby clarifying the meaning of the metaphor;

b. the nature of the interaction between tenor and vehicle is clarified by the language in which the metaphor is presented.

3. Ratings of comprehensibility and of aptness of metaphors should be significantly correlated. Comprehensibility is viewed as a necessary, but not

sufficient condition for aptness.

The first experiment investigated in particular the first hypothesis. Base statements were presented either in metaphorical or analogical form with two forced-choice options for completion of the statements. All elements in the metaphors from the underlying analogy were made explicit. Subjects were asked to complete the statements as quickly and as accurately as possible. The second experiment investigated all three hypotheses, concentrating in particular upon the second and third ones. This investigation dealt with intrarelationships among the various metaphorical forms in which differing numbers and identities of terms are left implicit, and investigated also the interrelationships of these metaphorical forms to analogies. This experiment presented subjects with the five metaphorical formats described earlier. These formats differed in the number of terms of the underlying analogy that were made explicit and in the order in which these terms were presented. The critical comparison, for our purposes, was between the second format (e.g., "Bees in a hive are a Roman mob") and the fifth format (e.g., "Bees are a Roman mob in a hive") (see Table 1). The formats are identical in the numbers and identities of the terms of the underlying analogy that is presented in the metaphor. But in the second format, the terms of the underlying analogy, A : B :: C : D, that are made explicit in the metaphor are presented in the order, A-B-C; in the fifth format, those terms are presented in the order, A-C-B. If correspondence to the underlying analogical form were all that mattered in determining the aptness of a metaphor, then the second format would be rated as more apt than the fifth. Yet, we predicted that metaphors in the fifth format would be rated as more apt than those in the second format, because we believed that the fifth format more encouraged

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subjects to form an interactive image relating the tenor and vehicle of the metaphor than did the second format, and that the creation of an interactive image linking tenor and vehicle would contribute more to aptness than would adherence to strict analogical form. This prediction was tested in the second experiment.

We wish to emphasize that we are claiming neither that our theory applies to all possible metaphors, nor that the theory (including representational elements in the Sternberg, Tourangeau, and Nigro, 1979, article) is a complete theory of metaphorical understanding. Rather, we believe that the theory deals with several interesting issues among many others in the metaphorical domain, and that it applies to an interesting subset of metaphors. For reviews of these and other theoretical issues, we refer readers to Billow (1977); Black (1962); Ortony (1979a, 1979b); Ortony, Reynolds, and Arter (1978); Tversky (1977); and Tourangeau and Sternberg (in press, Note 1).

Experiment 1

In this experiment, base statements were presented either in metaphorical or analogical form with two forced-choice options. Subjects completed the statements as quickly and accurately as possible, and were timed as they did so. Global and componential aspects of information processing were compared across tasks.

Method

Subjects. Subjects in the main part of the experiment were 96 students at Yale University who were paid for their participation in the experiment. Another

72 subjects provided various ratings needed in the mathematical modeling of the latency data, and 20 additional subjects provided ratings of interactive imagery for each of the 5 forms of the 50 metaphors used.

Materials. Experimental stimuli for subjects providing latencies were sentential metaphors and corresponding analogies typed in large (IBM ORATOR) capital letters on 4" x 6" index cards. All items ended with two possible completions, with subjects required to select the better of the two completions. A complete list of the 50 metaphors used in the experiment is shown in Table 1. The metaphors were gleaned from various psychological experiments reported in the literature, as well as from our own efforts at creation. Analogies were identical to the metaphors except for the deletion of mediating verbal context. For example, the metaphor, "A pear on a sill is a Buddha in a (a) temple, (b) puddle" would be presented as "pear : sill :: Buddha : (a) temple, (b) puddle."

Insert Table 1 about here

An attempt was made to construct metaphors that varied in their comprehensibility and in their aptness as well as in properties that were relevant to prediction of comprehension difficulty on the basis of the proposed theory of information processing. These aspects included relational distance between

1. the first and second analogy terms (used to estimate inference difficulty);
2. the first and third analogy terms (used to estimate mapping difficulty);
3. the third and ideal terms (used to estimate application difficulty);
4. the ideal and nonkeyed answer option (used to estimate comparison difficulty);
5. the relation between the first two terms and that between the third term and the keyed option (used to estimate justification difficulty).

This last distance should be zero if the analogy is perfect, and diverge from zero as the analogy becomes more imperfect. Encoding difficulty was manipulated by a precueing procedure described below, whereby differing numbers of terms were presented at different times on different experimental trials. Response component difficulty was not manipulated, since response was estimated as the regression constant.

Design. The two main independent variables were item format, which could be metaphorical or analogical, and condition of precueing (which could be either uncued or precued). These two variables were crossed with each other. Item format was a between-subjects variable, condition of precueing a within-subjects variable. In the uncued test trials, subjects received no advance information to facilitate their problem solving; in the cued test trials, subjects did receive such information. The main dependent variable was response time.

Mathematical modeling. Mathematical modeling was accomplished by predicting solution latencies for various metaphorical or analogical items from the independent variables. All independent variables were ratings except for that used to estimate encoding difficulty: Number of terms to be encoded, as manipulated by condition of precueing, was objectively determined. Modeling was done by linear multiple regression, using the SPSS REGRESSION program (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975). More detailed accounts of comparable mathematical modeling procedures can be found in Sternberg (1977a, 1977b, 1980, in press).

Apparatus. Metaphors and analogies were presented for response-time and response-choice measurement via a Gerbrands two-field tachistoscope with attached centisecond clock. In the ratings task, pairs of words (or in one case, pairs of pairs of words) were presented in booklets.

Procedure. In the metaphorical-presentation condition, subjects were told that they would see an incomplete statement followed by two words, for example, "The moon in the sky is a galleon in the (a) sea, (b) bath." They were then told that their task was to choose the better completion in as little time as possible. They were further told that

> trials will actually occur in two parts. In the first part of the trial, you will receive some amount of advance information. You should look at this advance information and do as much processing on it as you can. When you have finished looking at the advance information, press the bottom red button, which is in the middle of the button panel. The viewing field will become dark for about a second, and then the second part of the trial will begin. In the second part of the trial, you will always receive the full item. You should complete it, and then press the appropriate button on the button panel,...
>
> There are two conditions of advance information. Each represents successively more advance information. In one condition, you will see only a lighted blank field in the first part of the trial. Here there is no advance information. When you are ready to see the full problem, press the middle red button and about a second later, the full problem will appear. Solve the problem and press the correct answer button,...In the other condition, you will see only the phrase on the top line [subjects are shown "The moon in the sky is"] in the first part of the trial. You will not see the phrase in the middle [subjects are shown "a galleon in the"] or the two answer options [subjects are shown "(a) sea, (b) bath"]. You should look at the phrase and do as much processing as you can to help solve the problem. When you are ready, press the bottom red button. The full problem will then appear. Solve the problem and press the correct answer button.

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The 48 subjects in this condition received all 50 metaphors in one session. The actual test metaphors were preceded by some practice items, and succeeded by a full debriefing regarding the nature of the experiment. Although a given item was presented to a given subject only once, the items were divided into two quasiparallel forms so that each item type (where a type is defined by the relational distances relevant according to the componential theory of analogical reasoning) was presented once in each cueing condition. Order of cueing conditions was counterbalanced across subjects.

Procedure was the same in the analogical-presentation condition, except that the analogical format was substituted for the metaphorical one in the test items. There were also 48 subjects in this condition.

Subjects supplying ratings were divided into three groups. One group supplied ratings of the distance from the first to second, first to third, second to keyed, and third to keyed analogy terms. Another group supplied ratings of the distance from the third term to the imagined ideal response, from this imagined ideal response to the keyed option, and from the imagined ideal response to the unkeyed option. The third group supplied ratings of the distance between the relation of the first two terms and that of the third and keyed terms. Ratings were on scales of either 0-9 or 1-9, with higher values indicating greater distances. There were 24 subjects in each group.

Results[3]

Basic statistics. Mean response latencies were 3.84 and 3.90 seconds for the metaphorical and analogical item formats, respectively. The difference between these latencies was nonsignificant, regardless of whether t was computed across subjects or item types ($t < 1$ in each case). Error rates were .06 in each condition, and they, too, obviously did not differ

significantly across subjects or items ($t < 1$ in each case). These mean data are thus consistent with the notion that similar processing components were used in each task. The correlation between latencies (computed across item types) was .80; that between error rates was not meaningful because of the very low error rates on individual item types. The correlation between latencies needs to be considered in conjunction with the internal-consistency reliability of the latency data, which was .90 for metaphors and .93 for analogies. The comparison between the task intercorrelation and the task reliabilities shows that although processing of metaphors and analogies was probably highly similar in nature, it was not identical in nature, since there was still some systematic variance left unaccounted for. As mentioned earlier, at least some difference would be expected, since the metaphors supplied mediating context that was absent in the analogies, and presumably involved tenor-vehicle interaction.

Mathematical modeling. The data were modeled by predicting response latencies from the independent variables specified by the proposed theory of analogical and metaphorical reasoning. It became obvious that the data were not of sufficient quality to allow estimation of all of the parameters of the model. We therefore retained in the model the strongest four parameters, defined in terms of contribution to fit between predicted and observed data points. These four parameters were encoding, application, comparison, and justification. Fits of the model to the latency data can be determined by an examination of Table 2, which reports parameter estimates and various indices of fit for each condition. Parameters are expressed as standardized coefficients because the use of ratings made the raw coefficients nonmeaningful.

Insert Table 2 about here

As shown in the table, the overall fit of the model to each data set was quite good: Squared correlations between predicted and observed latencies were quite high, and differed significantly from zero. Root-mean-square deviations of observed from predicted values were reasonable, given the absolute levels of the latencies obtained in this experiment. Although the model fits were good, the models differed significantly in fit from the "true" model: In each data set, the residuals of observed from predicted values were statistically significant.[4] All but one of the parameter estimates differed significantly in value from zero, although only the value of encoding was closely matched across task formats. These results, like the earlier ones, can be interpreted as indicating that the proposed model provides a good fit to the data in each task and that information processing is highly similar, but not identical, in the two tasks.

An interesting feature of these data is that the proposed model fit the latencies for metaphors more closely than it fit the latencies for analogies. An interpretation of this finding that is consistent with the present conceptualization is that the higher fit is due to the metaphors providing more constraining context than do the analogies. This additional constraining context reduces individual differences in interpretation and thus increases uniformity in the way subjects apply the model to the metaphors. The outcome is increased fit of the model to the latency data.

Discussion

The results of this experiment show a high degree of similarity between metaphorical and analogical information processing both at a global and at a componential level. Mean latencies were almost identical, and a single model of information processing based upon the Sternberg (1977a, 1977b) theory of analogical reasoning provides a good fit to the data in each task format. Nevertheless, the subset of metaphors studied in this experiment was extremely restricted, limited as it was to proportional metaphors in which all terms are stated explicitly, the

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last as a choice of one of two answer options. One might well ask what relevance the proposed theory has for metaphors in which only some of the terms are explicitly stated. This question is addressed in Experiment 2, which also addresses the question of how useful the theory is in predicting aptness and comprehensibility of metaphors containing different numbers and identities of terms from the analogies underlying them.

Experiment 2

In this experiment, base statements were presented in each of several different metaphorical formats, where the formats differed in the number and identities of the terms of the underlying analogy that were left implicit. Subjects were asked to rate either the aptness or the comprehensibility of each metaphorical statement, and were timed with respect to the duration of the interval between presentation of the metaphor and communication of a rating.

Method

Subjects. Forty-eight Yale students uninvolved in Experiment 1 participated in the experiment, half making aptness ratings and half making comprehensibility ratings. Subjects received course credit for their participation. Ratings of independent variables in the information-processing model were taken from the "ratings" subjects of Experiment 1.

Materials. Stimuli in the second experiment were sentential metaphors adapted from the stimuli in the first experiment. Five forms of each metaphor were generated for the metaphors used in Experiment 1. Only the preferred answer option was used. An example of the five forms for the first metaphor in Table 1 is

1. Bees in a hive are a Roman mob in the Coliseum.
2. Bees in a hive are a Roman mob.
3. Bees are a Roman mob in the Coliseum.
4. Bees are a Roman mob.
5. Bees are a Roman mob in a hive.

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Note that all terms of the underlying analogy are presented in Form 1; in the other forms, the missing terms are the fourth in Form 2, the second in Form 3, the second and fourth in Form 4, and the fourth in Form 5. Form 5 differs from Form 2, where the fourth term was also left implicit, in the ordering of the explicitly given terms. All items were typed in large (IBM ORATOR) capital letters on white 9" X 12" construction paper.

Design. The two major independent variables were metaphorical form (1-5), which was a within-subjects variable, and type of rating to be made (aptness or comprehensibility), which was a between-subjects variable. Each subject received every one of the 50 metaphors in each of the five forms. Items were blocked by forms, and forms were presented in counterbalanced order via a Latin-square arrangement across subjects. Each subject thus received 250 items to rate. The main dependent variables were response latency to make the ratings and the ratings themselves.

Mathematical modeling. Mathematical modeling was done by linear multiple regression, as in Experiment 1.

Apparatus. Metaphors were presented via a portable tachistoscope with an attached centisecond clock.

Procedure. Subjects were instructed in either the aptness or the comprehensibility task. In the aptness task, subjects were told to rate aptness of the metaphors on a 1-9 scale, where higher ratings were associated with greater aptness. Subjects were told that aptness referred to "how appropriate or fitting a statement is." They were given as an example, "The moon in the sky is a ghostly galleon upon the sea," and asked: "Did this description of the moon immediately strike you as fitting (high in aptness) or did it strike you as inappropriate description of the moon (low in aptness)?" Subjects were told to decide upon an aptness rating, and state it aloud. The experimenter stopped the clock as soon as the rating was made. Instructions in the comprehensibility condition were similar, except that here subjects were told that "by comprehensibility we mean how easily understandable a statement is." The same example

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metaphor was given, and the subject was asked: "Did the meaning of this statement quickly come to mind (high comprehensibility) or did you have to ponder it for a time before its meaning came to mind (low comprehensibility)?" Comprehensibility ratings were stated aloud using a 1-9 scale, with higher numbers referring to higher levels of comprehensibility.

Results

Basic statistics. Table 3 shows mean ratings and response latencies for each of the forms in which the metaphors were presented. We shall consider rating and latencies of aptness and comprehensibility in turn, and then the relationships between them.

Insert Table 3 about here

For aptness, the effect of metaphorical form was highly significant both for ratings, $F(4,96) = 5.68$, $p < .001$, and for latencies to supply these ratings $F(4,96) = 18.42$, $p < .001$. An examination of the patterns of ratings and latencies makes clear the nature of the effects. Consider first Forms 1-4, those in which the terms are presented in the order corresponding to the underlying analogy. The highest rating and latency is achieved for the metaphors (Form 1) in which no terms are left implicit. Intermediate ratings and latencies are achieved for the metaphors (Forms 2 and 3) in which one term is left implicit. The lowest ratings and latency is achieved for the metaphors (Form 4) in which two terms are left implicit. Thus, when terms are presented in the natural A, B, C, D order corresponding to the order of the terms in the implicit analogy, the presentation of more terms is associated with higher aptness, but also higher latency to make the aptness ratings. Subjects take longer to process the greater amount of information, and presumably, the fuller encoding of the metaphorical relations they obtain is associated with the metaphor being rated as more apt. Form 5, where

the order of the second and third terms is reversed relative to the underlying implicit analogy, is rated as most apt, although its latency for rating is intermediate. The latencies of the various forms seem merely to reflect the amount of reading that is required: The form (4) with the smallest number of explicit terms has the lowest latency; the form (1) with the largest number of explicit terms has the highest latency; and the other forms (2, 3, 5) with intermediate numbers of missing terms have intermediate latencies. But the high Form 5 rating does not merely reflect its intermediate number of terms.

We believe that the Form 5 metaphor is rated as most apt because the juxtaposition of the terms supplies a kind of information additional to that supplied in the other metaphorical forms: In particular, it supplies information about the nature of the interaction between tenor and vehicle. In metaphors such as "A pear is a Buddha on a sill," or "Bees are a Roman mob in a hive," or "Tombstones are teeth in a graveyard," the tenor and vehicle are more easily seen to interact with each other, and it is especially easy in many cases to create an image of the nature of this interaction. One can easy imagine a Buddha transplanted to a window sill, a Roman mob scurrying about mindlessly in a hive, or teeth sticking up from the ground in a graveyard. Black (1962), Tourangeau and Sternberg (in press, Note 1), and others have suggested that metaphors attain one of their special qualities as figurative devices by the interaction between tenor and vehicle: It is this interaction that, in a certain sense, makes the metaphor come alive. The present results are consistent with this notion. The fifth form provides a juxtaposition of terms that facilitates one's understanding of the nature of the interaction between tenor and vehicle, and thus aptness is increased. In the other metaphorical forms, the absence of juxtaposition between the second and third terms leaves it to the reader to supply the nature of the interaction, and aptness is correspondingly reduced.

In order to test our hypothesis that the fifth metaphorical form encourages formation of interactive imagery more than does the second (or any other) metaphorical form, we had a separate group of twenty subjects rate "how vivid the interaction [was] between the two principle nouns" in each metaphor in each format (250 ratings in all). Mean ratings were 4.48 for Form 1 (Bees in a hive are a Roman mob in the Coliseum), 3.24 for Form 2 (Bees in a hive are a Roman mob), 3.00 for Form 3 (Bees are a Roman mob in the Coliseum), 2.91 for Form 4 (Bees are a Roman mob), and 4.77 for Form 5 (Bees are a Roman mob in a hive). A one-way analysis of variance revealed a significant effect of form, $F(4,96) = 70.00$, $p < .001$, and a planned follow-up contrast showed the ratings for Forms 1 and 5 to be higher than those for Forms 2,3, and 4. The most critical comparison, that between Forms 2 and 5, thus confirmed our prior hypothesis that although these two metaphors contained the same terms, the inversion of the B and C terms in Form 5 relative to the underlying analogy increased the interactive imagery stimulated by Form 5 relative to that stimulated by Form 2.

For comprehensibility, the effect of metaphorical form was marginally significant for ratings, $F(4,96) = 2.27$, $p \simeq .07$; for latencies to supply these ratings, the effect of form was highly significant, $F(4,96) = 17.81$, $p < .001$. The pattern of comprehensibility ratings echoes the pattern of aptness ratings, except for the inversion of the mean ratings for Forms 3 and 4. It is not clear what, if anything, this inversion means. For latencies, the amount of processing time spent on each form reflects the amount of reading to be done, as for the aptness-rating latencies.

In every case, ratings and latencies for comprehensibility were higher than their corresponding values for aptness. This contrast was not built into the analysis of variance, because the psychological meaning of a comparison between these ratings and latencies is not entirely clear. Nevertheless, the result is clearcut, and might be worthy of further exploration at some future time.

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To summarize, ratings of aptness and probability of comprehensibility increase as more information regarding implicit elements of the underlying analogy is given. Aptness and comprehensibility also increase as more information is given about the nature of the interaction between tenor and vehicle that makes the metaphor uniquely "metaphorical." Thus, understanding of the nature of metaphors based on analogies requires understanding both of the components of analogical reasoning used in metaphorical information processing, and of the conception of interaction that is unique to metaphor.

Relations between comprehensibility and aptness. The correlation between ratings of comprehensibility and of aptness was .61, $p < .001$, across the five forms, indicating that comprehensibility and aptness of metaphors are indeed related (as Tourangeau & Sternberg, in press, had found previously). Perhaps more interesting than the overall correlation across forms was the pattern of correlations within forms. For the five respective forms, the correlations (all significant) were .44 (Bees in a hive are Romans in the Coliseum), .63 (Bees in a hive are Romans), .65 (Bees are Romans in the Coliseum), .78 (Bees are Romans), and .48 (Bees are Romans in a hive). Of particular interest is the fact that the pattern of correlations is strongly inversely related to the pattern of means: Metaphorical forms with lower aptness and comprehensibility ratings are those that show the highest correlations within form between comprehensibility and aptness. This relationship between patterns of means and correlations is not an artifact of variance differences, such as those caused by floor and ceiling effects: The variances across the various conditions were practically indistinguishable from each other. Rather, there appears to be a stronger relationship between aptness and comprehensibility for metaphorical forms in which less information (about the underlying analogy or nature of the interaction between the tenor and vehicle) is given than for those in which more information is given. This pattern of results suggests that when metaphors are

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at the lower end of the comprehensibility scale, comprehensibility accounts for a relatively larger proportion of the variance in aptness: In these metaphors, there just isn't much other basis for judging metaphorical aptness. Once comprehensibility reaches a certain point, it becomes relatively less important in determining aptness, and more aesthetic kinds of factors may become more important. This pattern of results is consistent with our earlier hypothesis that comprehensibility is a necessary but not sufficient condition for aptness: After a certain threshold is reached, it ceases to make as much of a difference in aptness as it does before this threshold is reached. Gerrig and Healy (Note 5) failed to discover any relationship between comprehensibility and aptness, perhaps because their metaphors were generally more comprehensible than ours, and were thus above the point at which comprehensibility affects aptness. A visual inspection of their metaphors and ours is consistent with this interpretation.

Mathematical modeling. The mathematical modeling of the dependent variables in this experiment (latency, aptness ratings, and comprehensibility ratings) was less central to the data analysis of this experiment than it was to the data analysis of the previous experiment; it is nevertheless of some interest. Results of the mathematical modeling are shown in Table 4 for the two kinds of ratings and the latencies of each of the two kinds of ratings. Modeling

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Insert Table 4 about here

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was done for three sets of independent variables. The first included all parameters of the model of analogical reasoning plus aptness (used in the prediction

of comprehensibility ratings and latencies) or comprehensibility (used in the prediction of aptness ratings and latencies). The second set included only the full set of parameters of the model of analogical reasoning, but neither aptness nor comprehensibility. The third set included just mapping and justification, which were generally two of the strongest variables in the prediction equations.

Consider first the ratings data. All model fits differed significantly from zero, and most of them were fairly substantial. The full model seems to provide good prediction of the aptness and comprehensibility of metaphors, regardless of the form in which they are presented. This fact is of particular interest because although the full model was based upon all of the terms of the implicit analogy, all but one of the forms contained missing (implicit) terms. These results are consistent with the notion that subjects fill in missing terms. Prediction was best for the form containing two missing terms (e.g., "Bees are a Roman mob"), where mapping and justification alone were able to do quite well. Of particular interest is the great boost in R^2 attributable to interactive imagery as a predictor of aptness in Form 5, where interactive imagery was previously hypothesized to be especially important.

Consider next the latency data. Here, prediction was variable, and it was necessary to use the full model to obtain any reasonable level of predictive validity. The fact that the model provides any fit at all is of some interest, since there is no necessary a priori reason to expect it to predict latencies of ratings: The model was formulated only to predict comprehension latencies, which are presumably only one part of the ratings latencies. Indeed, it may be this part that the model successfully predicts.

Discussion

The results of this experiment suggest that metaphors tend to be rated as more comprehensible and more apt when more terms of the underlying implicit analogy are made explicit, and when the nature of the interaction between tenor and vehicle is made more easily perceptible. The experiment also suggests that the proposed model can describe imperfectly some of the factors that contribute to ratings of comprehensibility and aptness. The results are consistent with the notion that analogies underlie certain kinds of metaphors, but that comprehension and appreciation of these metaphors involve an appreciation of an interaction between domains that is not involved in the comprehension and appreciation of typical analogies.

General Discussion

The specific hypotheses posed in the introduction to this article were consonant with the data we obtained. The theory and data presented here were intended to address several broader issues in the theory of metaphor, however, and also have implications for certain other issues. We consider some of these issues here.

Relations between Analogy and Metaphor

On the present view, certain kinds of metaphors (so-called "proportional metaphors") are seen as based upon underlying analogies. The components of information processing used in understanding metaphors are viewed as highly overlapping with those used in understanding analogies. These components include the encoding, inference, mapping, application, comparison, justification, and response processes described earlier. There are also significant differences between the processing of analogies and metaphors, however. First, it is frequently the case that some of the terms of the underlying analogy are left implicit in a metaphor, so that the individual must construct these implicit terms, or closely related ones. Second, interpretation of an analogy usually does not seem to involve an interaction between domain and range (tenor and vehicle):

The two are interrelated but not integrated by the subject. Interpretation of a metaphor seems to involve an interaction between domain and range whereby each changes the perception of the other. Third, whereas the domain (first half) and range (second half) of an analogy may and often do derive from the same semantic subspace, the terms of a metaphor must derive from different semantic subspaces for the metaphor to be nontrivial. For example, the analogy "lion : wolf :: c[illegible] : dog" is perfectly acceptable as an analogy, but the metaphor "The lion is the wolf among cats" is trivial and uninteresting. Finally, the quality of an analogy is primarily a function of the fit between the domain and range: The relation between the first two terms must be as nearly parallel as possible to the relation between the second two terms. The quality of a metaphor is also determined in part by the fit between the domain and range (tenor and vehicle, or vice versa), but it is further determined by the distance between them. As shown above, a metaphor is trivial if the tenor and vehicle are from the same semantic subspace; the quality of a metaphor will improve as the semantic distance between tenor and vehicle increases in the semantic hyperspace that contains the two subspaces as points within it, up to the point where the subspaces begin to become unrelated or poorly related to each other (see Tourangeau & Sternberg, in press, Note 1).

The Nature of Interaction

On the present theory, an interaction between tenor and vehicle occurs when the semantic subspace containing the tenor of a metaphor is mentally superimposed upon the semantic subspace containing the vehicle of a metaphor (see Sternberg, Tourangeau, & Nigro, 1979). The domain is not only mapped onto the range of a metaphor (as takes place in an analogy), but also brought into juxtaposition with it: The tenor is seen in terms of the vehicle. This psychological juxtaposition of tenor and

vehicle can result in a shift in one's perceptions of the respective natures of the tenor and vehicle (i.e., in the location of each point within its respective subspace). Presumably the two points move into closer alignment such that their positions in their respective semantic subspaces become more nearly comparable.

Stages of Processing

A number of students of metaphor have asked whether or not metaphoric understanding occurs in two stages, the first of which is devoted to an attempt at literal interpretation and the second of which is devoted to an attempt at metaphorical interpretation (see Harris, 1976; Kintsch, 1974; Pollio, Barlow, Fine, & Pollio, 1977; Glucksberg, Hartman, & Stack, Note 6). On the present view, the notion of discrete stages of information processing for testing literal and then metaphorical interpretations of a statement is not appropriate. We view the distinction between a literal statement and a metaphorical one as graded. Strictly speaking, a literal statement would equate two elements in a single semantic subspace, whereas a metaphorical one would equate two elements from separate subspaces. The distance within the hyperspace would thus be zero in the first case (since the subspaces are the same point in the hyperspace) and greater than zero in the second case (since the subspaces are distinguishable points). In practice, however, if two terms from very proximal but nonidentical subspaces were equated, it might be difficult to judge whether the statement was intended as a literal or a metaphor. For example, the statement "People are humans" might be interpreted either literally or metaphorically. Surrounding context might help decide which interpretation is appropriate, as might qualification. The statement, "Those people aren't human" is clearly intended to be interpreted metaphorically. On our theory, processing time will generally tend to

increase as the distance between two semantic subspaces in their hyperspace (the identity of which can also be altered by context) increases, but it would be inappropriate to refer to the passage from one amount of distance to another as constituting a transition between stages. Indeed, the hardest statements to interpret might well be those in which the two terms of the statement are from close but nonidentical subspaces, in that these will tend to be the statements in which it is least clear whether a literal or metaphorical meaning is intended. The individual must therefore spend additional time figuring out just which meaning is, in fact, intended.

Factors Affecting Aptness and Comprehensibility of Metaphors

The present work in combination with the work of Tourangeau and Sternberg (in press) provides empirical evidence regarding several factors that affect the aptness and comprehensibility of metaphors. These include (a) each other (more apt metaphors are more comprehensible, and vice versa), (b) the degree of correspondence between locations of words in their respective semantic subspaces, (c) the distance between these subspaces in their semantic hyperspace, (d) the amount of information that is supplied about the implicit analogy underlying the metaphor, and (e) the amount of information that is supplied about the nature of the interaction between tenor and vehicle. These are not, by any means, the only factors affecting aptness of metaphors (see, e.g., Ortony, 1979a, 1979b; Tversky, 1977). But it is becoming more clear through research such as ours and that of others in the field that the aptness and comprehensibility of metaphors are complexly determined. Although we certainly do not know the identities of all of the factors that affect our understanding and appreciation of metaphors, we seem to be making headway in identifying them, and in recognizing what it is that distinguishes metaphor from other forms of communication.

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Footnotes

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[1]The use of a spatial representation for information is a theoretical and practical convenience rather than a claim about the way in which information is represented in the head. As is well known, different forms of representation are extremely difficult to distinguish (Anderson, 1978; Hollan, 1975), and we have shown how many of the concepts presented spatially in Tourangeau and Sternberg (in press) can be presented featurally instead (Tourangeau & Sternberg, Note 1). Thus, we look at a spatial representation as one of probably a number of difficult-to-distinguish representations people use in evaluating metaphors.

[2]No claim is made that this analogy uniquely generates any single metaphor, or that only one possible analogy underlies any given metaphor. Obviously, various logical permutations of terms are possible, as well as various insertions of terms left implicit in one or the other format.

[3]Results are presented from all data, including erroneous responses, which were a small proportion (.06) of responses. Results were practically identical when analyses were performed upon responses for correctly answered items only.

[4]Significance of residuals was determined by randomly dividing subjects into

two groups, fitting the proposed model to the data for each group, calculating the residuals of observed from predicted latencies in each group, correlating the residuals for the two groups, and correcting the obtained correlation by the Spearman-Brown formula. This correlation indicates the extent to which the residuals contain systematic variance within them.

Table 1

Set of Sentential Metaphors

Metaphor	Options	
	Keyed	Nonkeyed
1. Bees in a hive are a Roman mob in the	coliseum	aqueduct
2. A pear on a sill is a Buddha in a	temple	puddle
3. Blood on a wound is plush on a	carpet	magazine
4. Cattails in a field are nerves in a	body	dish
5. Tombstones in a graveyard are teeth in a	mouth	chair
6. The night before day is a sentinel before a	camp	test
7. Clouds in the sky are wedding dresses in a	window	radiator
8. A cactus in the desert is a candelabra on a	table	ceiling
9. A lamp on a dresser is a mushroom on a	stump	salad bowl
10. Stars in the heavens are carbonation in a	drink	lemon
11. Fungus on a rock is lace on a	dress	plate
12. Eyes of a head are turrets of a	castle	garden
13. Railroad tracks on the landscape are zippers on	garments	sneakers
14. The Milky Way in the heavens is foam on a	tide	pillow
15. A butterfly on the lawn is a bow in the	hair	hand
16. Crows on a wire are letters on a	line	pencil
17. An apricot on a tree is buttocks on a	body	portrait
18. Leaves on branches are kites on	strings	benches
19. Poppies in a field are flames of a	fire	stove
20. Crickets in the grass are gossipers at a	party	rocket
21. Clouds in the sky are jowls on a	face	plant

Table 1 (Contd.)

Metaphor	Options	
	Keyed	Nonkeyed
22. The SST among jets is Howard Cosell among	sports announcers	friends
23. Idi Amin among leaders is a piranha among	fish	children
24. Billboards on the roadside are warts on the	skin	nail
25. Dentists fighting decay are exorcists fighting	devils	churches
26. Snow on the ground is paste on a	board	napkin
27. The moon in the sky is a knuckle on a	hand	boot
28. A lighthouse at sea is a garnet in a	brooch	chimney
29. Encyclopedias of knowledge are mines of	gold	yarn
30. Cliches among expressions are hamburgers among	food	books
31. Hours of life are leaves of a	tree	can
32. Stomachs of bodies are dungeons of	castles	vases
33. Man on the earth is a feather in the	wind	branch
34. The heart in a body is a sponge in a	sink	television
35. The sky above land is a sail above a	deck	platform
36. The brain of a person is a spire of a	cathedral	blackboard
37. Polliwogs in the water are commas on a	page	shade
38. Memories in our heads are yellow pages in a	phonebook	blender
39. Sap from a tree is tears from a	child	flower
40. Spring for lovers is catnip for	cats	worms
41. Waves on the surf are ruffles on a	dress	baseball
42. Gems on a necklace are dew on a	spiderweb	snowflake
43. Man among creatures is a wolf among	animals	plants
44. Howard Hughes among men is the Big Foot among	animals	mountains
45. Cocaine of drugs is the caviar of	foods	drinks

Table 1 (Contd.)

Metaphor	Options	
	Keyed	Nonkeyed
46. Leonardo DaVinci among painters is the Rolls Royce among	cars	jewels
47. A nose on a face is a shell on a	beach	porch
48. Bandages on a body are moths on a	wall	fern
49. Levis for college students are fatigues for	soldiers	musicians
50. Skyscrapers in a city are giraffes among	animals	roses

Table 2

Mathematical Modeling of Latency Data in Experiment 1

Metaphorical Format

Overall Fit:

R^2	.86*
RMSD	.30 sec

Parameter Estimates:

Encoding	.46*
Application	.25*
Comparison	.22*
Justification	.68*

Analogical Format

Overall Fit:

R^2	.73*
RMSD	.60 sec

Parameter Estimates:

Encoding	.46*
Application	.58*
Comparison	.13
Justification	.24*

Note: R^2 represents the squared correlation between predicted and observed latencies for each data point. RMSD represents the root-mean-square deviation between predicted and observed latencies for each data point.

*$p < .01$

Table 3

Mean Ratings and Response Latencies

Form	Example	Rating	Latency
	Aptness		
1	Bees in a hive are a Roman mob in the Coliseum.	5.12	4.88
2	Bees in a hive are a Roman mob.	4.67	4.48
3	Bees are a Roman mob in the Coliseum.	4.66	4.66
4	Bees are a Roman mob.	4.32	3.93
5	Bees are a Roman mob in a hive.	5.27	4.54
	Comprehensibility		
1	Bees in a hive are a Roman mob in the Coliseum.	5.53	5.11
2	Bees in a hive are a Roman mob.	5.30	4.63
3	Bees are a Roman mob in the Coliseum.	5.01	4.86
4	Bees are a Roman mob.	5.17	4.13
5	Bees are a Roman mob in a hive.	5.70	4.66

Note: Ratings are expressed on a 1=low to 9=high scale. Latencies are expressed in seconds.

Table 4

Mathematical Modeling of Ratings of Aptness and Comprehensibility

Model	Form	Model Fits: Rating		Model Fits: Latencies	
		Aptness	Comprehensibility	Aptness	Comprehensibility
Full Analogical Model	1	.71	.78	.60	.49
+ Rating of Aptness	2	.77	.80	.39	.23
or Comprehensibility[a]	3	.69	.73	.61	.51
+ Rating of Interactive	4	.78	.86	.40	.61
Imagery	5	.71	.82	.58	.60
Full Analogical Model	1	.71	.77	.60	.47
+ Rating of Aptness	2	.75	.79	.30	.17
or Comprehensibility[a]	3	.54	.67	.60	.51
	4	.78	.83	.40	.22
	5	.51	.77	.45	.56
Full Analogical	1	.68	.75	.53	.46
Model	2	.67	.73	.29	.14
	3	.44	.60	.38	.25
	4	.75	.80	.38	.22
	5	.50	.77	.40	.52
Mapping and	1	.38	.51	.07	.20
Justification	2	.49	.62	.05	.02
Only	3	.35	.49	.00	.01
	4	.73	.67	.10	.08
	5	.39	.65	.04	.43

Note: Model fits are expressed as squared correlations between predicted and observed data points.

[a]Aptness was used as an independent variable in the prediction of comprehensibility; comprehensibility was used as an independent variable in the prediction of aptness.

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